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# BASIS OF DESIGN - INTEGRATED AUTOMATION

## CSI Division 25

### Pryor Data Center - PACHYDERM GLOBAL

**Parent Document:** [[Saga Pryor DC/Basis of Design/Erik\_BOD\_Updated/\_BOD - Exec Summary and TOC]]

## OVERVIEW

Integrated monitoring and control systems provide real-time visibility, automated optimization, and rapid fault response across electrical, mechanical, fire, and security systems. Microgrid controller coordinates 138kV utility, solar, BESS, and generators on common 11kV bus.

**System Integration Architecture:** - **BMS (Building Management System):** HVAC, lighting, environmental control - **EPMS (Electrical Power Monitoring System):** Utility, generators, UPS, transformers - **Microgrid Controller:** Coordinates utility, solar, BESS, generators at 11kV - **DCIM (Data Center Infrastructure Management):** Rack-level power, cooling, capacity - **Fire Alarm System:** Life safety integration (monitoring only) - **Access Control System:** Security integration

**Integration Layer:** BACnet/IP, Modbus TCP, OPC UA, SNMP

## BUILDING MANAGEMENT SYSTEM (BMS)

### System Scope

**HVAC Control & Monitoring:** - 12 × air-cooled chillers (Loops 1+2+3) - Chilled water pumps (primary + secondary) - 60 × CDUs (Phase 2, direct-to-chip cooling) - 30 × cabinet FCUs (fan speed, valve control) - DOAS units (white space pressurization, humidity control) - Rooftop units (office/support space comfort)

**Environmental Monitoring:** - Temperature sensors: Data halls (16+ points), mechanical rooms, offices - Humidity sensors: Data halls (8+ points), NOC - Differential pressure: White space pressurization monitoring - Leak detection: Data halls, mechanical rooms, CDU connections

**Lighting Control:** - Occupancy-based dimming in offices, conference rooms - Scheduled lighting in data halls (maintain minimum illumination 24/7) - Emergency lighting status monitoring

**Integration Interfaces:** - Fire alarm system (monitor status, trigger HVAC shutdown on alarm) - Access control (door status, HVAC zone coordination) - EPMS (utility status, generator run signals)

### BMS Platform

**Recommended Vendors:** - Schneider Electric EcoStruxure Building Operation - Siemens Desigo CC - Johnson Controls Metasys

**Architecture:** - **Head-end servers:** 2 × redundant servers (A/B, VM-based) - **Field controllers:** DDC controllers at each major equipment piece - Chiller plant: 3 × plant controllers (Loops 1+2 shared, Loop 3 separate) - Data hall: 6 × zone controllers (environmental, FCUs, DOAS) - Support spaces: 4 × zone controllers (RTUs, lighting, misc) - **Network:** Fiber backbone, copper to field devices - **Protocols:** BACnet/IP (primary), Modbus TCP (legacy integration) - **HMI:** Web-based graphical interface (HTML5, mobile-responsive)

### Control Strategies

**Free Cooling Optimization:** - Monitor outdoor air temperature (OAT) continuously - Mode 1: OAT <10°C → 100% free cooling (compressors off) - Mode 2: OAT 10-15°C → Partial free cooling (part-load compressors) - Mode 3: OAT >15°C → Full mechanical cooling - Target: 3,500-4,000 hrs/year free cooling in Pryor, OK

**Chiller Sequencing:** - Target 67% utilization per chiller for optimal efficiency - Rotate chillers weekly to equalize runtime - Stage chillers based on load (prevent short cycling)

**Pump VFD Control:** - Modulate pump speed to maintain differential pressure setpoint - ΔP setpoint: 15-20 psi at most remote cabinet/CDU - Reduce pumping energy during part-load conditions

**Supply Water Temperature Reset:** - Phase 1 (air cooling): 7-10°C supply, reset up during low load - Phase 2 (Loop 3 D2C): 25°C supply, fixed (optimal for GPUs)

**White Space Environmental Control:** - Maintain 18-27°C, 40-60% RH per ASHRAE A1 - DOAS modulates outdoor air dampers to maintain +0.02-0.05 in. w.g. pressure - Humidification/dehumidification staged based on RH sensors

### Alarms & Notifications

**Critical Alarms (Immediate Response):** - Chiller failure (redundancy loss) - Data hall high temperature (>27°C) - UPS on battery (utility loss) - Fire alarm activation - Leak detection - **Notification:** SMS + email + audible alarm in NOC

**Warning Alarms (Investigation Required):** - Equipment approaching setpoint limits - Maintenance due (filter replacement, oil change) - Low glycol level (makeup required) - **Notification:** BMS dashboard + email

**Escalation:** - If no acknowledgment within 15 minutes → escalate to backup on-call engineer - If no acknowledgment within 30 minutes → escalate to manager

## ELECTRICAL POWER MONITORING SYSTEM (EPMS)

### System Scope

**Medium Voltage Monitoring (11kV):** - 138kV/11kV substation transformers (2 × 25 MVA) - 11kV dual ring bus (Ring A + Ring B) - Ring main units (6 × RMUs, switching status) - 11kV/480V transformers (8 × 3,500 kVA)

**Generator Monitoring:** - 6 × 4.0 MW @ 11kV diesel generators - Parameters: kW, kVA, voltage, frequency, fuel level, run hours - Paralleling status, load sharing - Fuel tank levels (with low-level alarms)

**Low Voltage Monitoring (480V):** - Main switchboards (SWBD-A, SWBD-B) - Distribution panels (IT, mechanical, UPS output) - Branch circuits (major loads)

**IT UPS Monitoring:** - Phase 1: 5-6 × 1,250 kVA IT UPS modules (N+1 architecture) - Phase 2: 13-15 × 1,250 kVA IT UPS modules (N+1 architecture) - Parameters: Input/output kW, battery voltage, runtime remaining, bypass status, module health - Path redundancy: MV dual-ring provides path redundancy; N+1 UPS provides component redundancy

**Mechanical UPS Monitoring:** - 20 × 250 kW mechanical UPS modules (N+1) - Status, load, battery runtime

**Revenue Metering:** - Utility import/export at 138kV (utility-owned) - Solar production (11kV inverter output) - BESS charge/discharge (if BESS deployed)

### EPMS Platform

**Recommended Vendors:** - Schneider Electric PowerLogic / EcoStruxure Power Monitoring Expert - Siemens SICAM / PowerManager - GE Grid Solutions (if IEEE 2030.7/2030.8 microgrid controller required)

**Architecture:** - **SCADA server:** 2 × redundant servers (A/B) - **Power meters:** IEC 61850-compliant meters at all major points - 138kV substation: Utility-grade meters - 11kV ring bus: SEL or ABB relays with metering - 480V switchboards: Schneider PM8000 or equivalent - **Network:** Fiber (redundant ring topology) - **Protocols:** Modbus TCP, IEC 61850, DNP3

### Monitoring Functions

**Real-Time Power Flow:** - Single-line diagram (SLD) showing power flow from 138kV → 11kV → 480V → IT load - kW values at every major point (updated every 1-2 seconds)

**Load Trending:** - Historical power consumption (hourly, daily, monthly) - Peak demand tracking - PUE calculation (facility power / IT power)

**Fault Detection:** - Overcurrent, undervoltage, overvoltage, frequency deviation - Arc flash detection (optional) - Ground fault detection

**Generator Performance:** - Fuel consumption tracking (gal/hr, gal/kWh) - Runtime hours (maintenance scheduling) - Load sharing accuracy (verify equal load distribution)

## MICROGRID CONTROLLER (138kV/11kV SYSTEM)

### Purpose

Coordinates utility, solar, BESS, and generators on common 11kV bus infrastructure. Manages islanding (utility outage), load shedding, and seamless transitions between grid-connected and island modes.

### System Configuration

**Power Sources on 11kV Bus:** - 138kV utility (2 × 25 MVA transformers, 2N) - Solar array (8+ MW AC via 11kV inverters) - BESS (4-8 MWh via 11kV bi-directional inverters) - Generators (6 × 4.0 MW @ 11kV)

**Loads on 11kV Bus:** - Data center (8 × 11kV/480V transformers → IT + mechanical loads) - Auxiliary loads (minimal)

### Control Modes

**Mode 1: Grid-Connected (Normal Operation)** - Utility + Solar → Data Center Load - BESS: Charge from solar (if excess), discharge for peak shaving/demand response - Generators: Standby (periodic testing only) - Export: If permitted, sell excess solar to grid

**Mode 2: Island Mode (Utility Outage)** - Disconnect from utility at 138kV (automatic transfer switch or breaker) - Generators + Solar + BESS → Data Center Load - Generator black start (if needed) or BESS provides voltage reference - Solar output curtailed if load < generation (no export in island mode) - Duration: Unlimited (diesel fuel + solar during daylight)

**Mode 3: Transition Back to Grid (Utility Restored)** - Synchronize 11kV bus with utility (match voltage, frequency, phase) - Close utility breaker (seamless transfer) - Unload generators (ramp down over 5-10 minutes) - Resume normal grid-connected operation

### Microgrid Controller Specifications

**Standards Compliance:** - **IEEE 2030.7:** Microgrid Controller Standard - **IEEE 2030.8:** Testing Standard for Microgrid Controllers - **IEEE 1547:** Interconnection of Distributed Energy Resources

**Functions:** - **Islanding detection:** Detect utility loss, command disconnect - **Load shedding:** Drop non-critical loads if generation < load in island mode - **Generator dispatch:** Start/stop generators based on load/solar availability - **BESS control:** Charge/discharge commands based on grid status, solar output, load - **Solar curtailment:** Reduce solar output if overgeneration in island mode - **Synchronization:** Re-sync with utility when restored

**Recommended Vendors:** - GE Grid Solutions (Reason M60 or equivalent) - Schweitzer Engineering Labs (SEL microgrid controller) - ABB Ability OPTIMAX - Siemens SICAM (if SCADA-based microgrid control sufficient)

**Cost:** [ROM] $1.0-1.5M (IEEE 2030.7/2030.8 compliant controller + engineering)

### Benefits of Customer-Owned 138kV Substation + Microgrid

**Resiliency:** - True microgrid capability (island at 11kV during utility outage) - Solar + BESS + generators operate indefinitely without utility

**Flexibility:** - Export excess solar to grid (if permitted by utility) - Demand response participation (discharge BESS during grid peak events) - Future load growth (24 MW master plan) without utility upgrades

**Cost Savings:** - Avoid utility demand charges via peak shaving (BESS discharge during peaks) - Avoid utility interconnection fees for each new load addition - Single 11kV infrastructure for all power sources and loads

## DATA CENTER INFRASTRUCTURE MANAGEMENT (DCIM)

### System Scope

**Rack-Level Power Monitoring:** - 30 cabinets × 2 PDUs = 60 intelligent PDUs - Parameters: kW, kVA, voltage, current, power factor (per outlet or total) - Remote switching capability (if smart PDUs)

**Rack-Level Cooling Monitoring:** - Cabinet FCU status (fan speed, valve position, airflow) - CDU status (Phase 2: flow rate, supply/return temp, pump speed) - Temperature sensors: Rack inlet (cold aisle), outlet (hot aisle), rear door

**Environmental Sensors:** - Temperature: 4-6 sensors per cabinet (top, middle, bottom × inlet/outlet) - Humidity: 2 sensors per cabinet row - Airflow: Differential pressure across containment

**Asset Management:** - Rack inventory (server count, U-space utilization) - Customer assignment (which racks belong to which customer) - Equipment serial numbers, warranties, maintenance schedules

### DCIM Platform

**Recommended Vendors:** - Schneider Electric EcoStruxure IT / StruxureWare - Nlyte DCIM - Sunbird DCIM

**Features:** - **Real-time dashboards:** Power, cooling, environmental status - **Capacity planning:** “What-if” modeling for new equipment deployments - **Thermal mapping:** 3D visualization of data hall temperature distribution - **PUE calculation:** Real-time and historical PUE trending - **Customer portal:** Web interface for customers to view their rack metrics - **Change management:** Workflow for tracking equipment moves/adds/changes

### Key Metrics

**Power Usage Effectiveness (PUE):** - PUE = Total Facility Power / IT Power - Target: Phase 1 = 1.35, Phase 2 = 1.25 - Calculated every 5 minutes, trended over time

**Capacity Utilization:** - IT power: Actual kW / Available kW (%) - Cooling: Actual kW cooling load / Available kW cooling capacity (%) - Floor space: Occupied cabinets / Total cabinet positions (%)

**Thermal Performance:** - Rack inlet temp distribution (ensure <27°C per ASHRAE A1) - Hot spots identification (racks exceeding setpoint)

## NETWORK OPERATIONS CENTER (NOC)

### Purpose

24/7 monitoring and control hub for facility operations. NOC operators monitor BMS, EPMS, DCIM, fire, security systems and dispatch technicians for alarms.

### NOC Configuration

**Location:** Level 2, central spine (secure access)

**Equipment:** - 2-3 × operator workstations (dual monitors each) - Video wall: 3×3 or 4×2 LED display (55-65” panels) - Displays: BMS dashboards, EPMS single-line, DCIM capacity, CCTV feeds - Workstation PCs: Access to all monitoring systems - Printers: Log printing, alarm reports

**Staffing Options:** 1. **24/7 on-site:** 3 shifts × 2 operators = 6 FTEs 2. **Remote monitoring:** Off-site NOC, local on-call technician 3. **Hybrid:** On-site during business hours, remote nights/weekends

### NOC Responsibilities

**Monitoring:** - Watch for alarms from all integrated systems - Acknowledge alarms, log details - Monitor trends (power, cooling, environmental)

**Response:** - Dispatch on-call technicians for critical alarms - Coordinate with utility, fire department, security as needed - Execute emergency procedures (facility shutdown, evacuation)

**Coordination:** - Customer access requests (escort, remote hands) - Vendor access (maintenance, deliveries) - Shift handoff logs

## INTEGRATION PROTOCOLS & CYBERSECURITY

### Communication Protocols

**BACnet/IP:** - BMS devices (chillers, pumps, FCUs, sensors) - Native BACnet controllers preferred (no gateways)

**Modbus TCP:** - Legacy equipment integration (older UPS, generators) - Power meters (if not IEC 61850)

**IEC 61850:** - Medium voltage switchgear, relays, RMUs - Microgrid controller communication

**SNMP:** - Network equipment (switches, routers) - UPS monitoring (if BACnet not available)

**OPC UA:** - Industrial automation, SCADA - Microgrid controller integration with EPMS/BMS

### Network Architecture

**Segmentation:** - **IT Network:** Customer servers, internet gateway (isolated) - **Facility Network:** BMS, EPMS, DCIM, fire, security - **Management Network:** NOC workstations, admin access - **Firewall:** Between IT and Facility networks (strict rules)

**Redundancy:** - Fiber ring topology (dual path) - Redundant core switches (A/B) - UPS-backed network equipment

### Cybersecurity

**Access Control:** - Role-based access control (RBAC) for all systems - Multi-factor authentication (MFA) for remote access - Password policies (complexity, rotation)

**Encryption:** - TLS/SSL for all web interfaces - VPN for remote access

**Monitoring:** - Intrusion detection system (IDS) on facility network - Log aggregation and SIEM (if required by customer)

**Patching:** - Regular security updates for BMS/EPMS/DCIM servers - Tested in non-production environment before deployment

## COMMISSIONING & INTEGRATED SYSTEMS TESTING

### Functional Testing

**BMS Commissioning:** - Verify all points (sensors, control outputs) - Test control sequences (chiller staging, pump VFD, free cooling) - Alarm testing (trigger alarms, verify notification)

**EPMS Commissioning:** - Verify power meter accuracy (compare to portable meter) - Test generator auto-start on simulated utility loss - Verify load sharing between parallel generators

**Microgrid Controller Testing:** - **Islanding test:** Disconnect utility, verify seamless transition to generators + solar + BESS - **Load shedding test:** Reduce generation in island mode, verify non-critical loads drop - **Resynchronization test:** Restore utility, verify seamless transfer back to grid

**DCIM Commissioning:** - Verify rack PDU metering accuracy - Test environmental sensor calibration - Validate capacity planning models

### Integrated Systems Testing (IST)

**Scenario 1: Chiller Failure** - Simulate chiller failure (disable one unit) - Verify: Remaining chillers pick up load, no temperature excursion in data hall, alarm notification

**Scenario 2: Utility Loss** - Disconnect utility at 138kV - Verify: Generators auto-start, 11kV bus islands, IT load uninterrupted (IT UPS provides bridging) - Duration: Run for 4 hours to verify stability

**Scenario 3: Fire Alarm Activation** - Trigger fire alarm in data hall - Verify: HVAC shutdown, doors unlock, notification to fire department, no false suppression discharge

## COST SUMMARY

| System | Cost Estimate |
| --- | --- |
| **BMS (HVAC, Lighting, Environmental)** | $600-900K |
| **EPMS (Power Monitoring, SCADA)** | $400-600K |
| **Microgrid Controller (IEEE 2030.7/2030.8)** | $1.0-1.5M |
| **DCIM (Rack-Level Monitoring)** | $300-500K |
| **NOC Fit-Out (Workstations, Video Wall)** | $200-400K |
| **Integration & Engineering** | $300-500K |
| **Commissioning & IST** | $200-400K |
| **Total Integrated Automation** | **$3.0-4.8M** |

**Tags:** #pryor-dc #bms #epms #microgrid-controller #dcim #noc #ieee-2030

**Next Steps:** 1. Select BMS/EPMS/DCIM platforms (coordinate with equipment vendors) 2. Develop microgrid control strategy (islanding logic, load shedding priorities) 3. Design facility network architecture (fiber routing, switch locations) 4. Cybersecurity assessment and hardening plan 5. Commissioning plan with IST scenarios

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